U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 USC 371 AND 37 CFR 1.491

ATTORNEY DOCKET NO.: 401484

U.S. APPLICATION NO.: 10/009636

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/CH00/00417	August 4, 2000	August 9, 1999

TITLE OF INVENTION
ELECTRIC AXIAL FLOW MACHINE

APPLICANT(S) FOR DO/EO/US
KNORZER ET AL.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 USC 371 and 37 CFR 1.491.

2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 USC 371 and 37 CFR 1.491.

3. ☒ This is an express request to begin national examination procedures (35 USC 371(f)).

4. ☒ The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).

5. ☒ A copy of the International Application as filed (35 USC 371(c)(2))
   a. ☐ is attached hereto (required only if not communicated by the International Bureau).
   b. ☒ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).

6. ☐ An English language translation of the International Application as filed (35 USC 371(c)(2)).

7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 USC 371(c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.

8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 USC 371(c)(3)).

9. ☒ An oath or declaration of the inventor(s) (35 USC 371(c)(4)).

10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 USC 371(c)(5)).

11. Nucleotide and/or Amino Acid Sequence Submission
   a. ☐ Computer Readable Form (CRF)
   b. Specification Sequence Listing on:
      i. ☐ CD-ROM or CD-R (2 copies); or
      ii. ☐ Paper Copy
   c. ☐ Statement verifying identity of above copies

Items 12 to 19 below concern other document(s) or information included:

12. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
   ☒ Form PTO-1449
   ☒ Copies of Listed Documents

13. ☒ An assignment for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

14. ☒ A FIRST preliminary amendment.
   ☐ A SECOND or SUBSEQUENT preliminary amendment.

15. ☐ A substitute specification.

16. ☐ A change of power of attorney and/or address letter.

17. ☒ Application Data Sheet Under 37 CFR 1.76

18. ☒ Return Receipt Postcard

19. ☒ Other items or information: Drawings (4 sheets)

U.S. APPLICATION NO. 10/009636	INTERNATIONAL APPLICATION NO. PCT/CH00/00417	ATTORNEY DOCKET NO. 401484

20. ☐ The following fees are submitted:	CALCULATIONS	PTO USE ONLY
Basic National Fee (37 CFR 1.492(a)(1)-(5)):		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO $1,040.00		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO $890.00		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO, but international search fee (37 CFR 1.445(a)(2)) paid to USPTO $740.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) $710.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1) to (4) $100.00		
ENTER APPROPRIATE BASIC FEE AMOUNT=	$890.00	
Surcharge of $130.00 for furnishing the National fee or oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date	$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total Claims	11 -20=		x $ 18.00	$	
Independent Claims	1 - 3 =		x $ 84.00	$	
☐ Multiple Dependent Claim(s) (if applicable)			+$280.00	$	

TOTAL OF ABOVE CALCULATIONS=	$890.00	
☒ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.	$445.00	
SUBTOTAL=	$445.00	
Processing fee of **$130.00** for furnishing English Translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date.	$	
TOTAL NATIONAL FEE=	$445.00	
Fee for recording the enclosed assignment. The assignment must be accompanied by an appropriate cover sheet. **$40.00** per property +	$40.00	
TOTAL FEE ENCLOSED=	$485.00	
	Amount to be: refunded	$
	charged:	$

a. ☒ A check in the amount of $485.00 to cover the above fee is enclosed.

b. ☐ Please charge Deposit Account No. 12-1216 in the amount of $ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 12-1216. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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LEYDIG, VOIT & MAYER, LTD.
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Washington, DC 20005-3960
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Date: December 14, 2001

PATENT
Attorney Docket No. 401484/BRAUN

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

KNORZER et al.

Application No. Unknown

Filed: December 14, 2001

For: ELECTRIC AXIAL FLOW MACHINE

Art Unit: Unknown

Examiner: Unknown

PRELIMINARY AMENDMENT

Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

Prior to the examination of the above-identified patent application, please enter the following amendments and consider the following remarks.

IN THE DRAWINGS:

The Examiner is requested to approve the changes to Figures 1, 3, 6, and 10 as indicated in the attached Request for Approval of Drawing Amendments.

IN THE SPECIFICATION:

Before the paragraph beginning at page 1, line 3, insert as a heading:

Field of the Invention

Amendments to the paragraph beginning at page 1, line 2:

The present invention relates to an electric axial flow machine.

Before the paragraph beginning at page 1, line 6, insert as a heading:

Background

Before the paragraph beginning at page 2, line 21, insert as a heading:

Summary of the Invention

Amendments to the paragraph beginning at page 2, line 21:

In view of the disadvantages of the previously known axial flow motors and generators, the invention is based on the following object. The aim is to provide an electric axial flow machine, the rotor of which is as low in mass and inertia as possible, but nevertheless stable and also suitable for high rotational speeds.

Delete the paragraph beginning at page 2, line 30.

Amendments to the paragraph beginning at page 2, line 37:

An important feature of the invention is that, in an electric axial flow machine with an ironless disk-shaped rotor which is arranged on a machine shaft and has permanent magnets which are embedded in a fiber- or fabric-reinforced plastic, the permanent magnets are each joined with a positive fit to the surrounding fiber- or fabric-reinforced plastic and the latter, together with the permanent magnets and the machine shaft, forms a dimensionally stable unit. Arranged next to the rotor on both sides there is in each case a stator.

Before the paragraph beginning at page 3, line 36 insert as a heading:

Brief Description of the Drawing Figures

Amendments to the paragraph beginning at page 4, line 5:

figure 2 shows the axial flow machine in a partial sectional view along the line II-II in figure 1;

Amendments to the paragraph beginning at page 4, line 13:

figure 4 shows the rotor including the machine shaft in a partial sectional view along the line IV-IV in figure 3;

Amendments to the paragraph beginning at page 4, line 23:

figure 7 shows a sectional view of the segmented permanent magnet along the line VII-VII in figure 6;

Amendments to the paragraph beginning at page 4, line 36:

figure 11 shows a sectional view of the stator along the line XI-XI in figure 10.

Before the heading at page 5, line 1 insert as a heading:

Detailed Description

IN THE CLAIMS:

Replace the indicated claims with:

1. (Amended) An electric axial flow machine including an ironless disk-shaped rotor arranged on a machine shaft and having permanent magnets embedded in a fiber- or fabric-reinforced plastic, and, on both sides, next to the rotor, a stator, wherein the permanent magnets are each joined to the surrounding fiber- or fabric-reinforced plastic so that the permanent magnets and the machine shaft , form a dimensionally stable unit.

2. (Amended) The electric axial flow machine as claimed in claim 1, wherein the permanent magnets are arranged in a circle around the machine shaft and the fiber- or fabric-reinforced plastic extends between the permanent magnets over at least 10%, of the circle.

3. (Amended) The electric axial flow machine as claimed in claim 1, wherein the rotor has on an outer circumference or proximate the outer circumference a stiffening band comprising preimpregnated fibrous material, the rotor becoming thicker with increasing distance from the machine shaft.

4. (Amended) The electric axial flow machine as claimed in claim 1, comprising means for determining magnetic pole position of the rotor including a magnetic strip arranged on an outer circumference of the rotor and having a radially magnetized series of magnetic poles arranged in correspondence to the permanent magnets embedded in the fiber- or fabric-reinforced plastic, and fixed-in-place Hall probes interacting with the magnetic poles.

5. (Amended) The electric axial flow machine as claimed in claim 1, wherein the fiber- or fabric-reinforced plastic comprises an epoxy resin or an imide resin with glass fiber reinforcement.

6. (Amended) The electric axial flow machine as claimed in claim 1, wherein the permanent magnets respectively comprise at least two separate magnet segments next to one another, in a circumferential direction, joined by a metal adhesive.

7. (Amended) The electric axial flow machine as claimed in claim 1, wherein the stator comprises an annular yoke including slots extending approximately radially and through which multi-phase windings pass.

8. (Amended) The electric axial flow machine as claimed in claim 7, wherein one of the permanent magnets and the slots are transposed in a circumferential direction.

9. (Amended) The electric axial flow machine as claimed in claim 1, including two stators electrically offset in relation to one another in a circumferential direction by 180° so that magnetic fluxes in the circumferential direction in the rotor are oppositely oriented and essentially cancel one another.

10. (Amended) A method for producing a rotor for an electric axial flow machine as claimed in claim 1, wherein the machine shaft and the permanent magnets are arranged in a mold and a pre-heated fiber- or fabric-reinforced plastic is subsequently poured under pressure into the mold, which is heated.

11. (Amended) The method as claimed in claim 10, including pouring the fiber- or fabric-reinforced plastic at a temperature of at least 200°C and under a pressure of 500 - 1500 bar.

IN THE ABSTRACT:

Insert the following abstract:

Abstract Of The Disclosure

An electric axial flow machine includes an ironless disk-shaped rotor arranged on a machine shaft and having permanent magnets embedded in a fiber- or fabric-reinforced plastic, and, on both sides, next to the rotor, a stator, wherein the permanent magnets are each

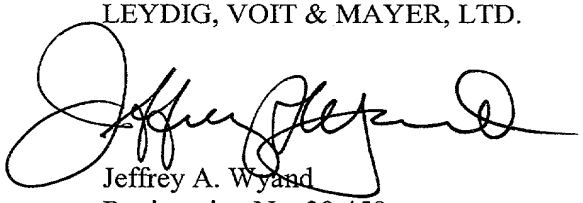
joined to the surrounding fiber- or fabric-reinforced plastic so that the permanent magnets and the machine shaft form a dimensionally stable unit.

REMARKS

The foregoing Amendment corrects translational errors and conforms the claims to United States practice. No new matter is added.

Respectfully submitted,

LEYDIG, VOIT & MAYER, LTD.



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Date: December 14, 2001
JAW:ves

PATENT
Attorney Docket No. 401484/BRAUN

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

KNORZER et al.

Application No. Unknown

Filed: December 14, 2001

For: ELECTRIC AXIAL FLOW MACHINE

Art Unit: Unknown

Examiner: Unknown

AMENDMENTS TO SPECIFICATION, CLAIMS AND ABSTRACT MADE VIA PRELIMINARY AMENDMENT

Before the paragraph beginning at page 1, line 3, insert as a heading:

Field of the Invention

Amendments to the paragraph beginning at page 1, line 2:

The present invention relates to an electric axial flow machine ~~as defined in the precharacterizing clause of the independent patent claim 1~~.

Before the paragraph beginning at page 1, line 6, insert as a heading:

Background

Before the paragraph beginning at page 2, line 21, insert as a heading:

Summary of the Invention

Amendments to the paragraph beginning at page 2, line 21:

In view of the disadvantages of the previously known axial flow motors and generators, the invention is based on the following object. The aim is to provide an electric axial flow machine ~~of the type mentioned at the beginning~~, the rotor of which is as low in mass and inertia as possible, but nevertheless stable and also suitable for high rotational speeds.

Delete the paragraph beginning at page 2, line 30.

Amendments to the paragraph beginning at page 2, line 37:

~~The essence~~An important feature of the invention is that, in an electric axial flow machine with an ironless disk-shaped rotor which is arranged on a machine shaft and has permanent magnets which are embedded in a fiber- or fabric-reinforced plastic, the permanent magnets are each joined with a positive fit to the surrounding fiber- or fabric-reinforced plastic and the latter, together with the permanent magnets and the machine shaft, forms a dimensionally stable unit. Arranged next to the rotor on both sides there is in each case a stator.

Before the paragraph beginning at page 3, line 36 insert as a heading:

Brief Description of the Drawing Figures

Amendments to the paragraph beginning at page 4, line 5:

figure 2 shows the axial flow machine in a partial sectional view along the line ~~E-E~~ II-II in figure 1;

Amendments to the paragraph beginning at page 4, line 13:

figure 4 shows the rotor including the machine shaft in a partial sectional view along the line ~~A-A~~ IV-IV in figure 3;

Amendments to the paragraph beginning at page 4, line 23:

figure 7 shows a sectional view of the segmented permanent magnet along the line ~~C-C~~ VII-VII in figure 6;

Amendments to the paragraph beginning at page 4, line 36:

figure 11 shows a sectional view of the stator along the line ~~D-D~~ XI-XI in figure 10.

Before the heading at page 5, line 1 insert as a heading:

Detailed Description

Amendments to existing claims:

1. (Amended) An electric axial flow machine ~~with~~ including an ironless disk-shaped rotor ~~(1) which is~~ arranged on a machine shaft ~~(2)~~ and ~~has~~ having permanent magnets ~~(11) which are~~ embedded in a fiber- or fabric-reinforced plastic ~~(12)~~, and, on both sides, next to the rotor ~~(1) in each case,~~ a stator ~~(3, 4), characterized in that~~ wherein the permanent magnets ~~(11)~~ are each joined ~~with a positive fit~~ to the surrounding fiber- or fabric-reinforced plastic ~~(12) and the latter, together with~~ so that the permanent magnets ~~(11)~~ and the machine shaft ~~(2), forms~~ form a dimensionally stable unit.

2. (Amended) The electric axial flow machine as claimed in claim 1, ~~characterized in that a plurality of~~ wherein the permanent magnets ~~(11)~~ are arranged in a ~~circular manner~~ circle around the machine shaft ~~(2)~~ and the fiber- or fabric-reinforced plastic ~~(12), in particular a thermosetting material,~~ extends between the permanent magnets ~~(11) altogether~~ over at least 10%, ~~preferably between 15% and 20%,~~ of the circle.

3. (Amended) The electric axial flow machine as claimed in claim 1 ~~or 2~~, wherein ~~characterized in that~~ the rotor ~~(1)~~ has on ~~the~~ an outer circumference or ~~in the vicinity of~~ proximate the outer circumference a stiffening band ~~(13), which comprises~~ comprising preimpregnated fibrous material, ~~which preferably contains glass, carbon or Kevlar fibers, and, for stiffening purposes,~~ the rotor ~~(1) is preferably formed such that it becomes~~ becoming thicker ~~from the inside outward~~ with increasing distance from the machine shaft.

4. (Amended) The electric axial flow machine as claimed in ~~one of claims~~ claim 1 ~~to 3, characterized in that it has~~ comprising means for determining ~~the~~ magnetic pole position of the rotor ~~(1), which preferably comprise~~ including a magnetic strip ~~(14) which is~~ arranged on ~~the~~ an outer circumference of the rotor ~~(1)~~ and ~~forms~~ having a radially magnetized series of magnetic poles ~~, which are respectively~~ arranged in ~~a way corresponding~~ correspondence to the permanent magnets ~~(11)~~ embedded in the fiber- or fabric-reinforced plastic ~~(12)~~, and fixed-in-place Hall probes ~~(5)~~ interacting with ~~said~~ the magnetic poles.

5. (Amended) The electric axial flow machine as claimed in ~~one of claims~~ claim 1 ~~to 4, characterized in that~~ wherein the fiber- or fabric-reinforced plastic ~~(12)~~ comprises an epoxy resin or an imide resin with glass fiber reinforcement ~~and preferably, for better thermal expansion and thermal conductivity, additionally comprises mineral substances~~.

6. (Amended) The electric axial flow machine as claimed in ~~one of claims~~ claim 1 ~~to 5, characterized in that~~ wherein the permanent magnets ~~(11)~~ respectively comprise at least two separate magnet segments ~~(111)~~ next to one another, in ~~the~~ a circumferential direction, ~~which are preferably~~ joined by ~~means of~~ a metal adhesive.

7. (Amended) The electric axial flow machine as claimed in ~~one of claims~~ claim 1 ~~to 6, characterized in that~~ wherein the ~~stators (3, 4) each comprise~~ stator comprises an annular yoke ~~(31, 41), in which~~ including slots ~~(32, 42)~~ extending approximately radially ~~from the inside outward have been made,~~ and through which ~~slots~~ multi-phase windings ~~(33, 43) are led~~ pass.

8. (Amended) The electric axial flow machine as claimed in ~~one of claims 1 to~~ claim 7, ~~characterized in that~~ wherein one of the permanent magnets ~~(11) or~~ and the slots ~~(32, 42)~~ are transposed in ~~the~~ a circumferential direction.

9. (Amended) The electric axial flow machine as claimed in ~~one of claims~~ claim 1 ~~to 8, characterized in that the~~ including two stators ~~(3, 4) are~~ electrically offset in relation to one another in ~~the~~ a circumferential direction by 180°~~, with the result that the corresponding~~ so that magnetic fluxes in the circumferential direction in the rotor ~~(1)~~ are oppositely oriented and ~~consequently~~ essentially cancel one another ~~out in practice, at least for the most part~~.

10. (Amended) A method for producing a rotor ~~(1)~~ for an electric axial flow machine as claimed in ~~one of claims~~ claim 1 ~~to 9, characterized in that a~~ wherein the machine shaft ~~(2)~~ and the permanent magnets ~~(11)~~ are arranged in a mold and a pre-heated fiber- or fabric-reinforced plastic is subsequently poured under pressure into the mold, which is heated.

11. (Amended) The method as claimed in claim 10, ~~characterized in that the~~ including pouring ~~in of~~ the fiber- or fabric-reinforced plastic ~~takes place~~ at a temperature of at least 200°C and under a pressure of 500 - 1500 bar.

Insert the following abstract:

Abstract Of The Disclosure

An electric axial flow machine includes an ironless disk-shaped rotor arranged on a machine shaft and having permanent magnets embedded in a fiber- or fabric-reinforced plastic, and, on both sides, next to the rotor, a stator, wherein the permanent magnets are each joined to the surrounding fiber- or fabric-reinforced plastic so that the permanent magnets and the machine shaft form a dimensionally stable unit.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

KNORZER et al.

Application No. Unknown

Filed: December 14, 2001

For: ELECTRIC AXIAL FLOW MACHINE

Art Unit: Unknown

Examiner: Unknown

PENDING CLAIMS AFTER ENTRY OF PRELIMINARY AMENDMENT

1. An electric axial flow machine including an ironless disk-shaped rotor arranged on a machine shaft and having permanent magnets embedded in a fiber- or fabric-reinforced plastic, and, on both sides, next to the rotor, a stator, wherein the permanent magnets are each joined to the surrounding fiber- or fabric-reinforced plastic so that the permanent magnets and the machine shaft , form a dimensionally stable unit.

2. The electric axial flow machine as claimed in claim 1, wherein the permanent magnets are arranged in a circle around the machine shaft and the fiber- or fabric-reinforced plastic extends between the permanent magnets over at least 10%, of the circle.

3. The electric axial flow machine as claimed in claim 1, wherein the rotor has on an outer circumference or proximate the outer circumference a stiffening band comprising preimpregnated fibrous material, the rotor becoming thicker with increasing distance from the machine shaft.

4. The electric axial flow machine as claimed in claim 1, comprising means for determining magnetic pole position of the rotor including a magnetic strip arranged on an outer circumference of the rotor and having a radially magnetized series of magnetic poles arranged in correspondence to the permanent magnets embedded in the fiber- or fabric-reinforced plastic, and fixed-in-place Hall probes interacting with the magnetic poles.

5. The electric axial flow machine as claimed in claim 1, wherein the fiber- or fabric-reinforced plastic comprises an epoxy resin or an imide resin with glass fiber reinforcement.

6. The electric axial flow machine as claimed in claim 1, wherein the permanent magnets respectively comprise at least two separate magnet segments next to one another, in a circumferential direction, joined by a metal adhesive.

7. The electric axial flow machine as claimed in claim 1, wherein the stator comprises an annular yoke including slots extending approximately radially and through which multi-phase windings pass.

8. The electric axial flow machine as claimed in claim 7, wherein one of the permanent magnets and the slots are transposed in a circumferential direction.

9. The electric axial flow machine as claimed in claim 1, including two stators electrically offset in relation to one another in a circumferential direction by 180° so that magnetic fluxes in the circumferential direction in the rotor are oppositely oriented and essentially cancel one another.

10. A method for producing a rotor for an electric axial flow machine as claimed in claim 1, wherein the machine shaft and the permanent magnets are arranged in a mold and a pre-heated fiber- or fabric-reinforced plastic is subsequently poured under pressure into the mold, which is heated.

11. The method as claimed in claim 10, including pouring the fiber- or fabric-reinforced plastic at a temperature of at least 200°C and under a pressure of 500 - 1500 bar.

PATENT
Attorney Docket No. 401484/BRAUN

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

KNORZER et al.

Art Unit: Unknown

Application No. Unknown

Examiner: Unknown

Filed: December 14, 2001

For: ELECTRIC AXIAL FLOW MACHINE

REQUEST FOR APPROVAL OF CHANGES TO THE DRAWINGS

Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

The Examiner is requested to approve the changes to Figures 1, 3, 6, and 10, as shown in red on the attached sheets of drawings.

Respectfully submitted,

LEYDIG, VOIT & MAYER, LTD.

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Date: December 14, 2001
JAW:ves

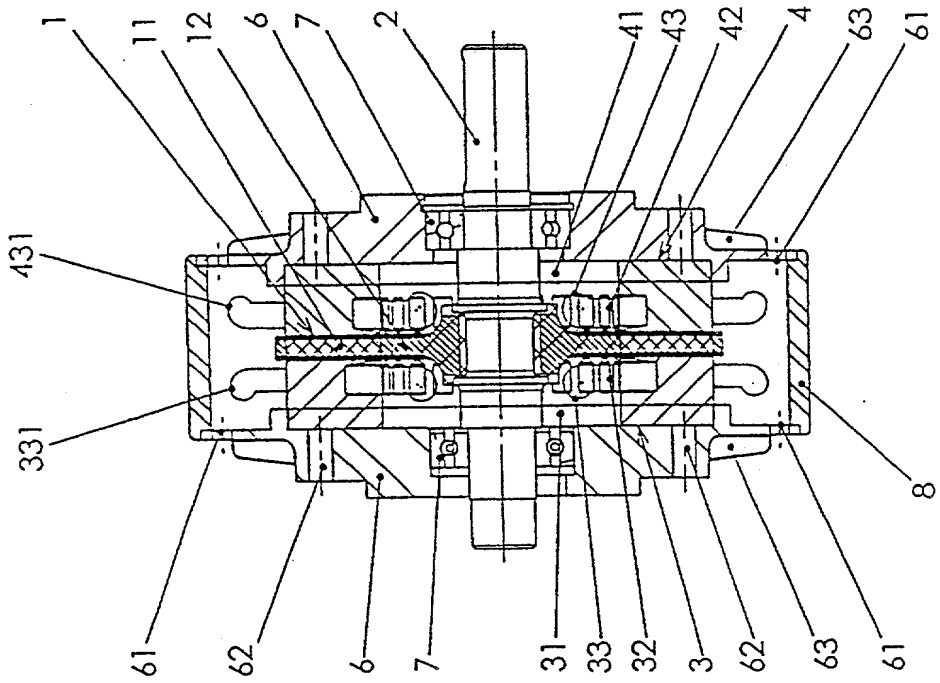
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Fig.2

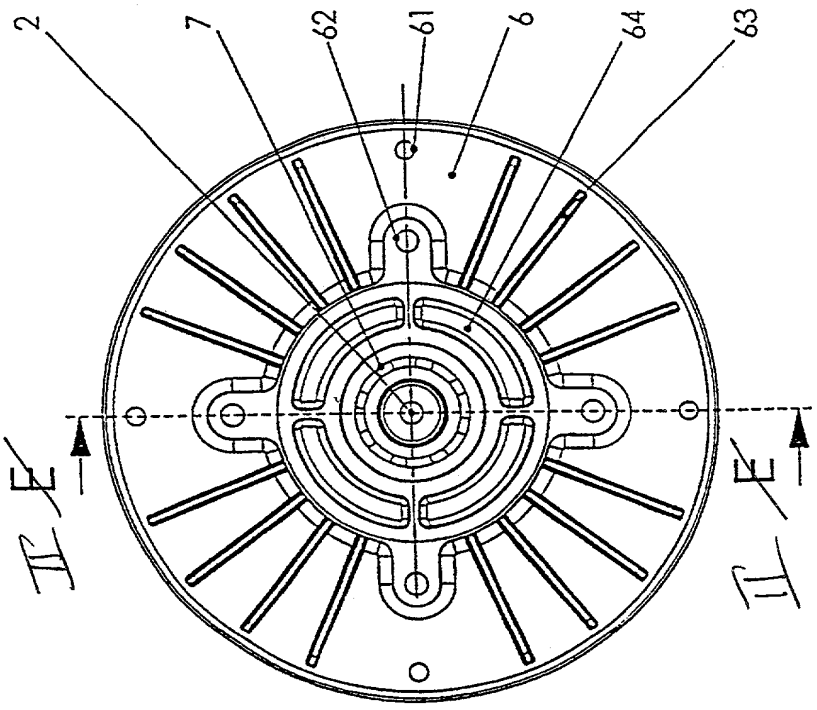
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Fig.1

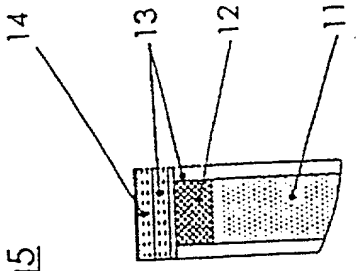


Fig5

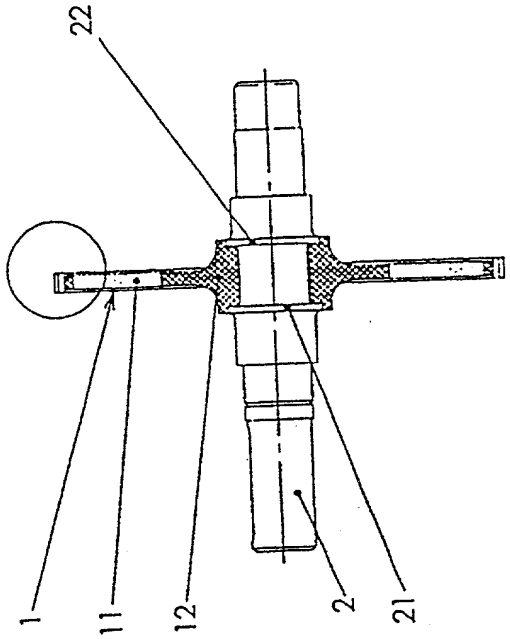


Fig.4

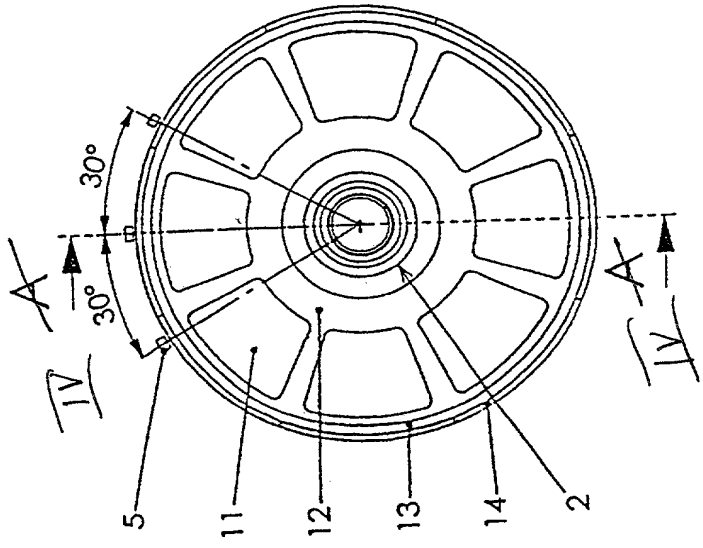


Fig.3

Fig.6

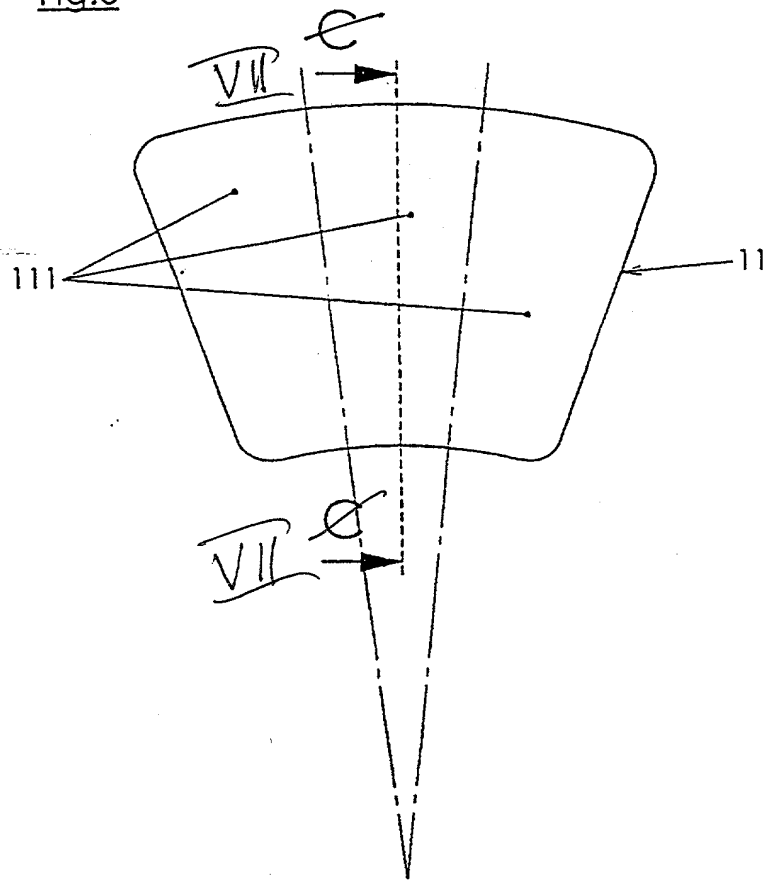


Fig.7

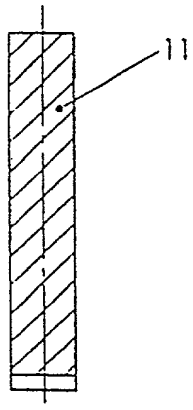


Fig.8

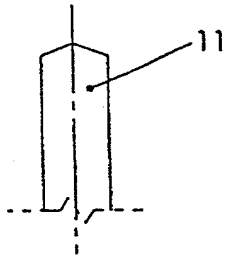
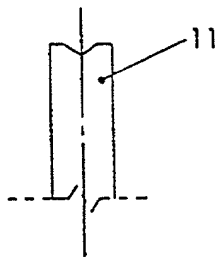


Fig.9



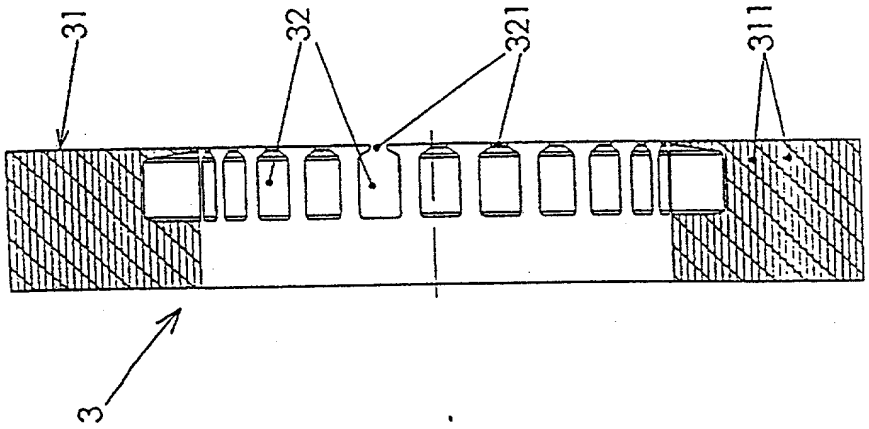


Fig.11

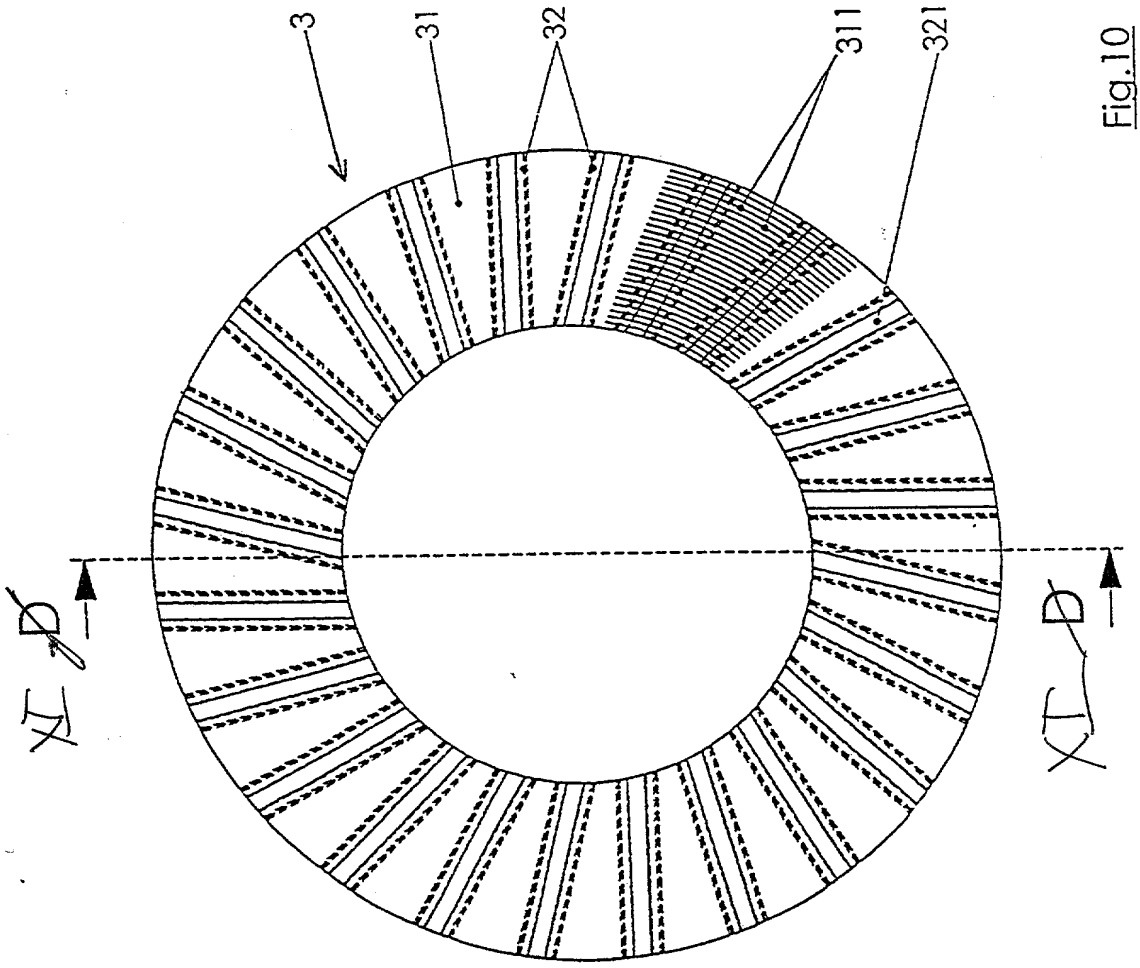


Fig.10

4/pats

Electric axial flow machine

The present invention relates to an electric axial flow machine as defined in the precharacterizing clause of the independent patent claim 1.

An electric axial flow machine is understood as meaning a motor or generator with a rotor and a stator, in which the magnetic flux between the rotor and the stator takes place parallel to the axis of rotation of the rotor. Axial flow machines of this type are also known by the designations brushless DC motor, permanent-field synchronous motor or disk-armature motor.

An efficient brushless DC motor with an ironless rotor arranged around a shaft and having permanent magnets is described for example in DE-U-298 16 561. In the case of this DC motor, arranged around the shaft on both sides of the disk-shaped rotor, and parallel to the rotor, there is in each case an electromagnet unit as a stator. The rotor has permanent magnets which are arranged in a circular manner around the shaft, are embedded for example in a plastic and the direction of magnetization of which runs parallel to the shaft. Two neighboring permanent magnets respectively have a reversed direction of magnetization. One stator is provided with first electromagnetic regions and the other stator is provided with second electromagnetic regions, the number of which corresponds to the number of permanent magnets, two neighboring first electromagnetic regions and two neighboring second electromagnetic regions in each case having reversed directions of magnetization, which are changed alternately. The first and second electromagnetic regions are arranged offset in relation to one another and have a phase difference of 90°.

One disadvantage of this DC motor is that the rotor is, by its nature, relatively unstable and therefore suitable only for slow rotations.

US-A-5 619 087 discloses an electric axial flow machine which comprises at least two ironless disk-shaped rotors with relatively small, bar-shaped permanent magnets, which are embedded in a fiber- or fabric-reinforced plastic. A plurality of like-magnetized permanent magnets arranged next to one another respectively form a group, which forms one magnetic pole. The fact that many relatively small permanent magnets are arranged in the plastic instead of a number of large magnets has the effect of reducing the effective magnetic area, and consequently the magnetic flux, which is compensated by the use of at least two rotors. Furthermore, the anchoring of the many individual permanent magnets in the plastic presents problems in terms of production and strength.

In view of the disadvantages of the previously known axial flow motors and generators, the invention is based on the following object. The aim is to provide an electric axial flow machine of the type mentioned at the beginning, the rotor of which is as low in mass and inertia as possible, but nevertheless stable and also suitable for high rotational speeds.

This object is achieved by the electric axial flow machine according to the invention as defined in the independent patent claim 1. Patent claim 10 relates to a method according to the invention for producing a rotor for an electric axial flow machine of this type. Preferred design variants emerge from the dependent patent claims.

The essence of the invention is that, in an electric axial flow machine with an ironless disk-shaped rotor

which is arranged on a machine shaft and has permanent magnets which are embedded in a fiber- or fabric-reinforced plastic, the permanent magnets are each joined with a positive fit to the surrounding fiber- or fabric-reinforced plastic and the latter, together with the permanent magnets and the machine shaft, forms a dimensionally stable unit. Arranged next to the rotor on both sides there is in each case a stator.

The mere fact that the plastic is fiber- or fabric-reinforced means that the rotor has great rigidity. This is further increased by the fact that the permanent magnets are each joined with a positive fit to the surrounding fiber- or fabric-reinforced plastic and the latter, together with the permanent magnets and the machine shaft, forms a dimensionally stable unit. The latter can be achieved by suitable arrangement of the permanent magnets and the machine shaft and molding of the fiber- or fabric-reinforced plastic. The design of the rotor according to the invention makes the rigid permanent magnets serve at the same time as stiffening elements, it being ensured by the positive connection with the surrounding plastic that the permanent magnets do not become detached.

A plurality of permanent magnets are advantageously arranged in a circular manner around the machine shaft, and the plastic, in particular a thermosetting material, advantageously extends between the permanent magnets altogether over at least 10%, preferably between 15% and 20%, of the circle. By arranging and embedding the permanent magnets in such a way, the rotor can be optimally designed with regard to strength and efficiency.

The axial flow machine according to the invention is described in more detail below on the basis of an exemplary embodiment with reference to the attached drawings, in which:

figure 1 shows an axial flow machine according to the invention in a side view;

figure 2 shows the axial flow machine in a partial sectional view along the line E-E in figure 1;

figure 3 shows the rotor with machine shaft and with means for determining the magnetic pole position of the rotor in a side view;

figure 4 shows the rotor including the machine shaft in a partial sectional view along the line A-A in figure 3;

figure 5 shows an enlarged view of a detail of the rotor from figure 4;

figure 6 shows a plan view of a segmented permanent magnet;

figure 7 shows a sectional view of the segmented permanent magnet along the line C-C in figure 6;

figure 8 shows a permanent magnet with a first special contour for the positive connection with the surrounding plastic;

figure 9 shows a permanent magnet with a second special contour for the positive connection with the surrounding plastic;

figure 10 shows a stator in a side view; and

figure 11 shows a sectional view of the stator along the line D-D in figure 10.

Figures 1 and 2

The axial flow machine according to the invention which is shown comprises a disk-shaped rotor 1, which is securely connected to a machine shaft 2 and has permanent magnets 11, which are embedded in a fiber-reinforced plastic 12, for example a thermosetting material. Arranged on both sides of the rotor 1 there is in each case, parallel to the latter, an annular stator 3 and 4, which is respectively fastened to a bearing plate 6. The stators 3, 4 each have an annular yoke 31 and 41 with slots 32 and 42 on their sides facing the rotor 1, in which slots multi-phase windings 33 and 43 which have external winding overhangs 331 and 431 are led. The bearing plates 6 are preferably made of aluminum and also have stiffening and cooling ribs 63, with the result that the heat generated is dissipated well. Clearances 64 in the bearing plates 6 have the purpose of reducing the weight. For mounting the bearing plates 6, bolt holes 61 are provided, while threaded holes 62 serve for fastening them on a machine part, not shown, for example a gear mechanism. The bearing plates 6 and an annular casing part 8 together form a casing for the rotor 1 and the stators 3, 4. The machine shaft 2 is rotatably mounted on the bearing plates 6 by means of ball bearings 7.

The two stators 3, 4 are electrically offset in relation to one another in the circumferential direction by 180°, with the result that the corresponding magnetic fluxes produced in the circumferential direction in the rotor 1 are oppositely oriented and consequently cancel one another out in practice, at least for the most part. This makes it possible to dispense with an iron in the rotor 1.

The following statement applies to the entire further description. If reference numerals are contained in a figure for the purpose of elucidating the drawing but

are not mentioned in the directly associated text of the description, or vice versa, reference is made to their explanation in previous descriptions of figures.

Figures 3 to 5

According to the invention, the rotor 1 and the machine shaft 2 form a dimensionally stable unit. The ironless disk-shaped rotor 1 has eight permanent magnets 11, which are arranged in a circular manner around the machine shaft 2 and are embedded in the fiber-reinforced plastic 12. The fiber-reinforced plastic 12 extends between the permanent magnets 11 altogether over between approximately 15% and 20% of the circle, to be precise in such a way that uniform webs are formed. In this way, there is sufficient fiber-reinforced plastic 12 between the mechanically very rigid permanent magnets 11 for the rotor 1 to be stable, and a rotor 1 with the smallest possible mass moment of inertia is achieved with the greatest economy in terms of production.

The machine shaft 2 is also embedded in a central region in the fiber-reinforced plastic 12, two flanges 21 and 22 providing a stable connection between the rotor 1 and the machine shaft 2.

For absorbing the centrifugal forces, attached to the outer circumference of the rotor 1 is a stiffening band 13, which comprises preimpregnated fibrous material, which preferably contains glass, carbon or Kevlar fibers predominantly aligned in the circumferential direction. The stiffening band 13 is wider than the permanent magnets 11 and the fiber-reinforced plastic 12, which can be clearly seen in particular in figure 5. It is advantageous for stiffening purposes for the fiber-reinforced plastic 12 and the permanent magnets 11 also to be formed such that they become thicker from the inside outward.

Adhesively attached on the outside around the stiffening band 13 is a magnetic strip 14, which forms a radially magnetized series of magnetic poles, which are respectively arranged in a way corresponding to the permanent magnets 11 embedded in the fiber-reinforced plastic 12, although 100% of the circumference is covered. This magnetic strip 14 makes it possible to determine the magnetic pole position of the rotor 1 at the periphery by means of three fixed-in-place Hall probes 5. The three Hall probes 5 are spaced apart from one another in the circumferential direction by 30° each and are arranged for example on a printed circuit, which is fastened to the casing part 8. The determined magnetic pole position allows the firing angle for the multi-phase windings 33, 43 of the stators 3, 4 to be optimally set.

The permanent magnets 11 preferably consist of sintered magnetic material, for example NdFeB, with a flexural strength of approximately 270 N/mm^2 and a modulus of elasticity of approximately 150 kN/mm^2. The fiber-reinforced plastic 12 is, for example, an epoxy resin or an imide resin with glass fiber reinforcement. The mechanical strength values achieved here too lie in the range of steel 37. The heat resistance for the epoxy resin lies around 200°C and for the imide resin lies around 250°C. For better thermal expansion and thermal conductivity, mineral substances may be additionally added to the resin.

To produce the rotor 1, the machine shaft 2 and the permanent magnets 11 are arranged in a mold and the pre-heated fiber-reinforced plastic is subsequently poured under pressure into the mold, which is heated. Depending on the resin, the pouring-in of the fiber-reinforced plastic takes place at a temperature of at least 200°C or at least 250°C and under a pressure of 500 - 1500 bar. This causes plastication, which

ensures complete filling of the mold and a good positive fit with the permanent magnets 11 and the machine shaft 2.

Figures 6 and 7

In the case of the present exemplary embodiment, the permanent magnets 11 respectively comprise three separate magnet segments 111 next to one another in the circumferential direction. This allows the eddy current losses to be reduced. The magnet segments 111 are preferably joined by means of a metal adhesive, but may also be held together only by the fiber-reinforced plastic 12.

Figures 8 and 9

Since a great intrinsic rigidity of the rotor 1 is essential at high rotational speeds and with relatively small air gaps between the rotor 1 and the stators 3, 4, the permanent magnets 11 are each joined with a positive fit to the surrounding fiber-reinforced plastic 12. Shown in figures 8 and 9 are two possible magnet contours, which are suitable for absorbing the shearing forces occurring.

In the case of the rotor 1 shown, it is possible to dispense with the attachment on both sides of magnetically conductive plates for holding the permanent magnets 11 or a similar kind of sandwich design, whereby the mass inertia, the amount of magnetic material and the surface losses can be kept low and undesired leakage paths between neighboring permanent magnets 11 can be avoided.

Figures 10 and 11

The construction of the two stators 3, 4 is explained below on the basis of the example of the stator 3. The

stator 3 comprises an annular yoke 31, in which slots 32 extending approximately radially from the inside outward have been made. The yoke 31 is made up of a plurality of layers 311 of high-quality dynamo sheet, which are rolled during the slot punching to form assemblies and are subsequently connected by a weld point. The slots 32 are relatively wide in the interior of the yoke 32, but toward the rotor 1 have a relatively narrow opening 321.

As shown in figure 2, multi-phase windings 33, for example three-phase windings, are led through the slots 32. Accommodating the multi-phase windings 33 in the slots 32 allows the stator 3 to be brought close to the permanent magnets 11 of the rotor 1, i.e. there is a very small air gap, which has the consequence of a very high magnetic flux and consequently a very great power density.

On account of a transposing of the slots 32 in the circumferential direction and with respect to the permanent magnets 11 of the rotor 1, latching moments and noises can be minimized.

Further design variations can be realized in respect of the axial flow machine described above. The following are also expressly mentioned here:

- The determination of the magnetic pole position of the rotor 1 does not necessarily have to take place by means of the magnetic strip 14 and the Hall probes 5. Also conceivable, inter alia, is an optical scanning of light and dark regions on the periphery of the rotor 1.

- Instead of transposing the slots 32, and consequently the multi-phase windings 33 led in them, the permanent magnets 11 may also be transposed.

- Instead of being fiber-reinforced, the plastic 12 of the rotor 1 may also be fabric-reinforced.

Patent claims

1. An electric axial flow machine with an ironless disk-shaped rotor (1) which is arranged on a machine shaft (2) and has permanent magnets (11) which are embedded in a fiber- or fabric-reinforced plastic (12), and on both sides next to the rotor (1) in each case a stator (3, 4), characterized in that the permanent magnets (11) are each joined with a positive fit to the surrounding fiber- or fabric-reinforced plastic (12) and the latter, together with the permanent magnets (11) and the machine shaft (2), forms a dimensionally stable unit.

2. The electric axial flow machine as claimed in claim 1, characterized in that a plurality of permanent magnets (11) are arranged in a circular manner around the machine shaft (2) and the fiber- or fabric-reinforced plastic (12), in particular a thermosetting material, extends between the permanent magnets (11) altogether over at least 10%, preferably between 15% and 20%, of the circle.

3. The electric axial flow machine as claimed in claim 1 or 2, characterized in that the rotor (1) has on the outer circumference or in the vicinity of the outer circumference a stiffening band (13), which comprises preimpregnated fibrous material, which preferably contains glass, carbon or Kevlar fibers, and, for stiffening purposes, the rotor (1) is preferably formed such that it becomes thicker from the inside outward.

4. The electric axial flow machine as claimed in one of claims 1 to 3, characterized in that it has means for determining the magnetic pole position of

the rotor (1), which preferably comprise a magnetic strip (14) which is arranged on the outer circumference of the rotor (1) and forms a radially magnetized series of magnetic poles, which are respectively arranged in a way corresponding to the permanent magnets (11) embedded in the fiber- or fabric-reinforced plastic (12), and fixed-in-place Hall probes (5) interacting with said magnetic poles.

5. The electric axial flow machine as claimed in one of claims 1 to 4, characterized in that the fiber- or fabric-reinforced plastic (12) comprises an epoxy resin or an imide resin with glass fiber reinforcement and preferably, for better thermal expansion and thermal conductivity, additionally comprises mineral substances.

6. The electric axial flow machine as claimed in one of claims 1 to 5, characterized in that the permanent magnets (11) respectively comprise at least two separate magnet segments (111) next to one another in the circumferential direction, which are preferably joined by means of a metal adhesive.

7. The electric axial flow machine as claimed in one of claims 1 to 6, characterized in that the stators (3, 4) each comprise an annular yoke (31, 41), in which slots (32, 42) extending approximately radially from the inside outward have been made, through which slots multi-phase windings (33, 43) are led.

8. The electric axial flow machine as claimed in one of claims 1 to 7, characterized in that the permanent magnets (11) or the slots (32, 42) are transposed in the circumferential direction.

9. The electric axial flow machine as claimed in one of claims 1 to 8, characterized in that the two stators (3, 4) are electrically offset in relation to one another in the circumferential direction by 180°, with the result that the corresponding magnetic fluxes in the circumferential direction in the rotor (1) are oppositely oriented and consequently cancel one another out in practice, at least for the most part.

10. A method for producing a rotor (1) for an electric axial flow machine as claimed in one of claims 1 to 9, characterized in that a machine shaft (2) and permanent magnets (11) are arranged in a mold and a pre-heated fiber- or fabric-reinforced plastic is subsequently poured under pressure into the mold, which is heated.

11. The method as claimed in claim 10, characterized in that the pouring-in of the fiber- or fabric-reinforced plastic takes place at a temperature of at least 200°C and under a pressure of 500 - 1500 bar.

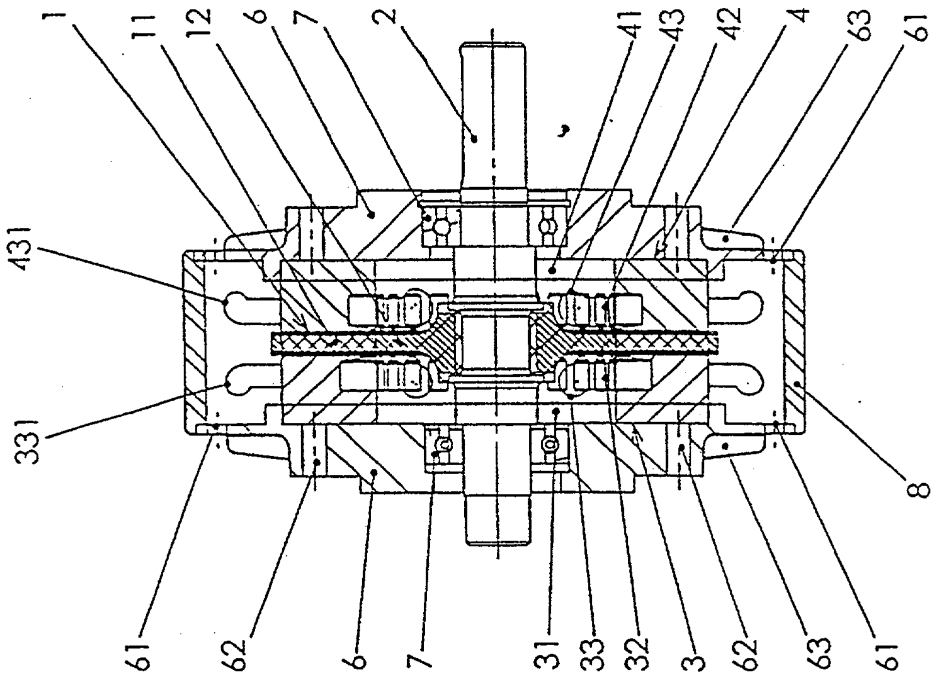

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Fig.2

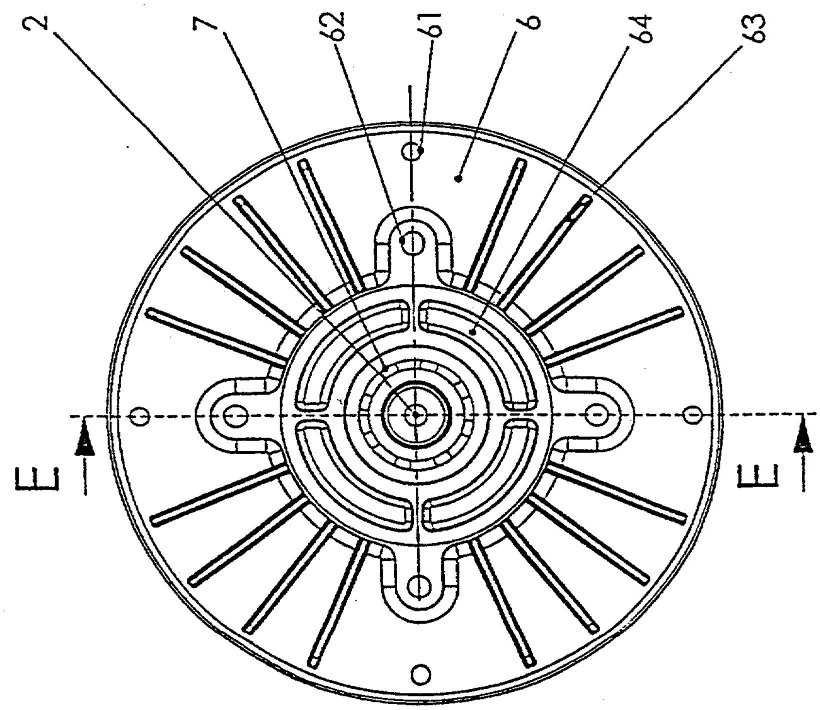
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Fig.1

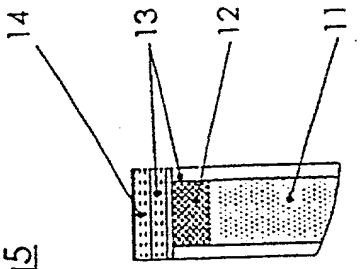


Fig5

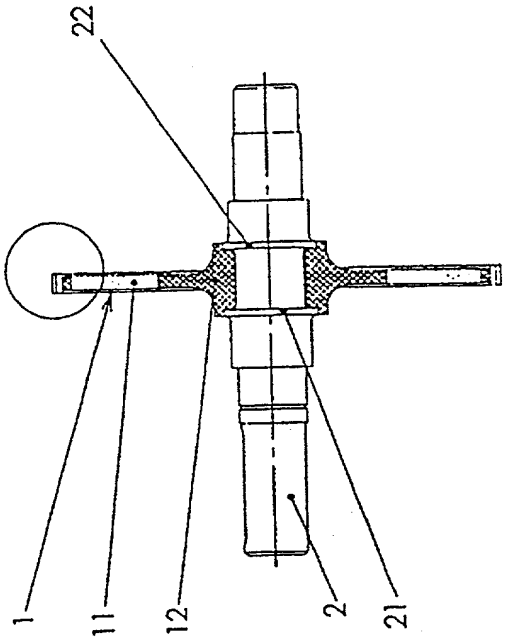


Fig.4

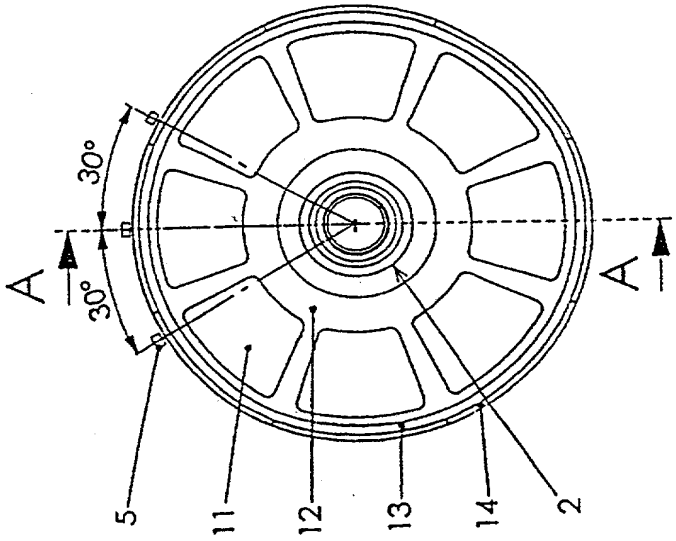


Fig.3

Fig.6

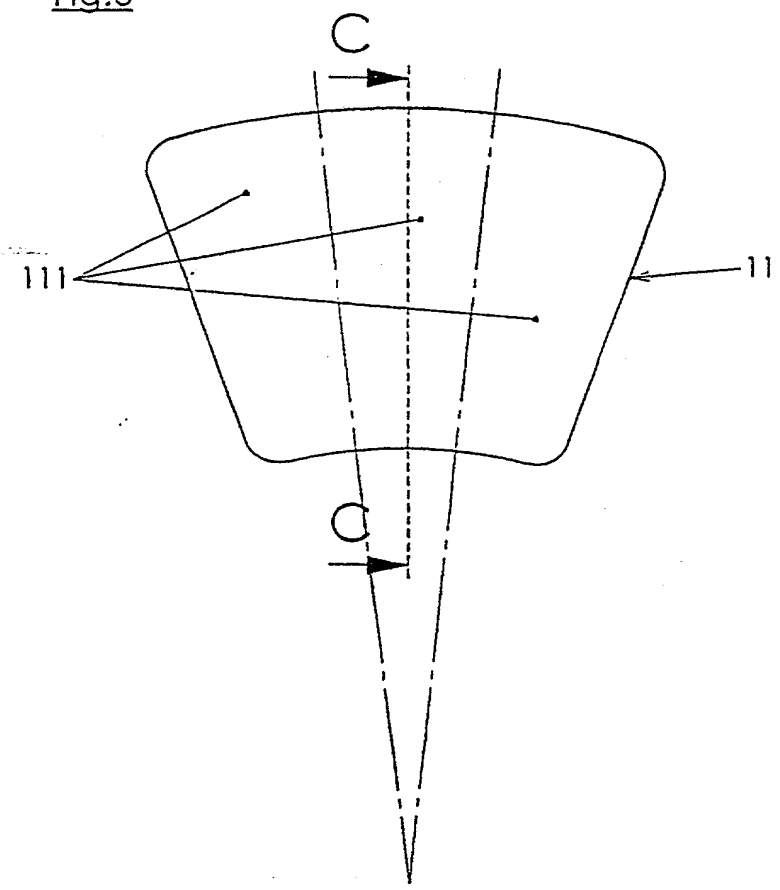


Fig.7

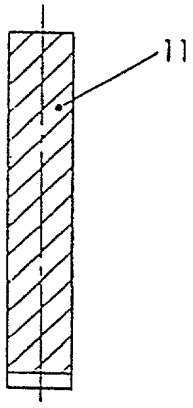


Fig.8

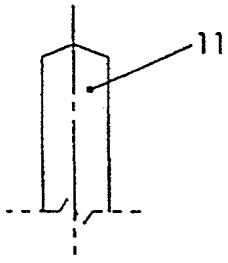
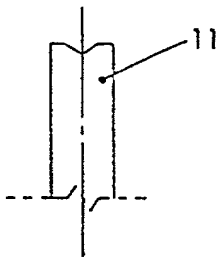


Fig.9



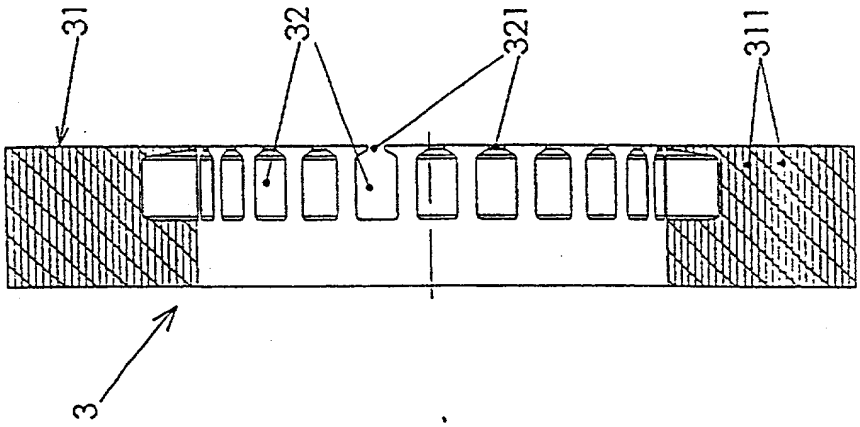


Fig.11

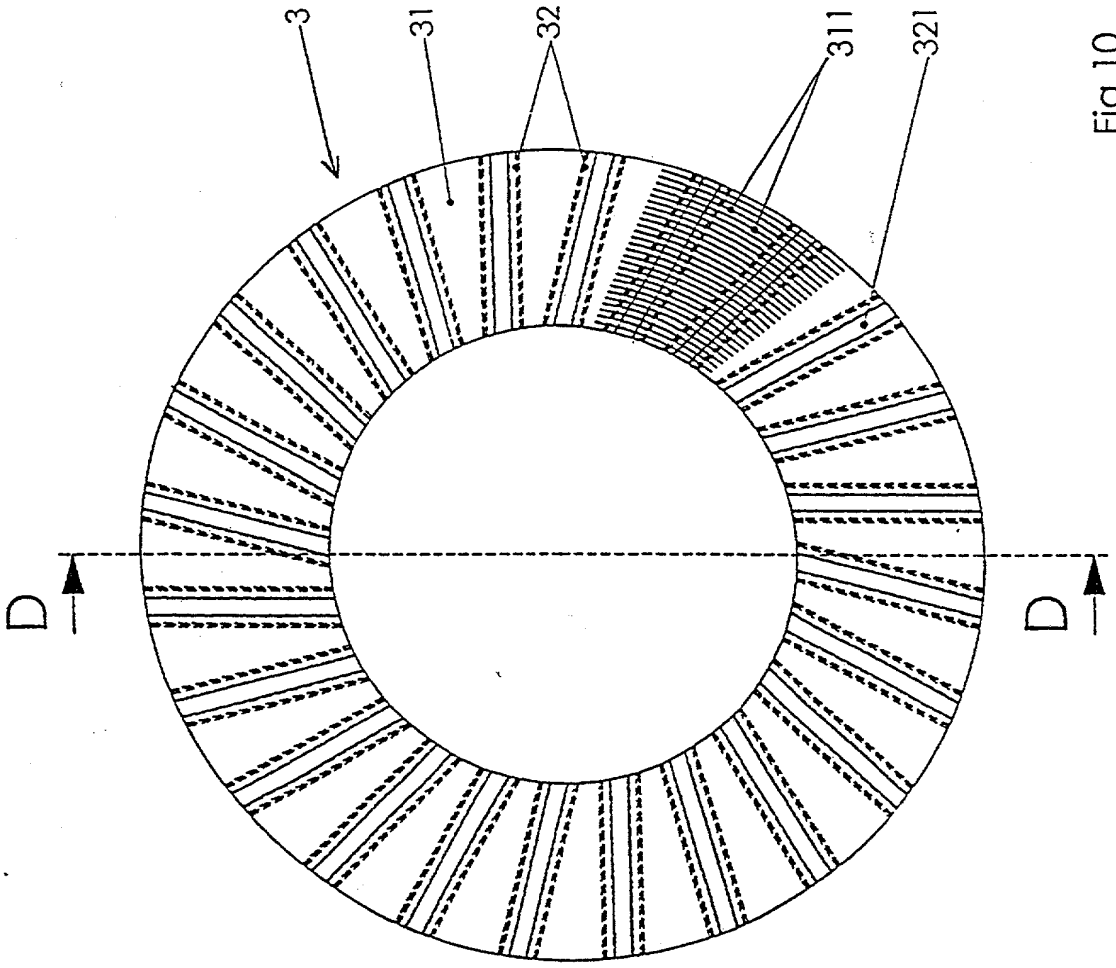


Fig.10

PATENT

Attorney Docket No. _____

COMBINED DECLARATION AND POWER OF ATTORNEY

This declaration is of the following type:

☐ original ☐ design ☐ supplemental
☒ national stage of PCT
☐ divisional ☐ continuation ☐ continuation-in-part

As a below named inventor, I hereby declare that

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first, and sole inventor *(if only one name is listed below)* or an original, first, and joint inventor *(if plural names are listed below)* of the subject matter which is claimed and for which a patent is sought on the invention entitled:

ELECTRIC AXIAL FLOW MACHINE

the specification of which:

☐ is attached hereto.
☐ was filed on _____ as Serial No. _____ and was amended on _____ *(if applicable)*.
☒ was described and claimed in PCT International Application No. PCT/ CH00/00417 filed on August 04, 2000 and as amended pursuant to PCT Article 19 on _____ *(if any)*.

I state that I have reviewed and understand the contents of the specification identified above, including the claim(s), as amended by any amendment referred to above.

I acknowledge the duty to disclose information that is material to the examination of the application identified above in accordance with 37 CFR §1.56.

I claim foreign priority benefits pursuant to 35 USC §119(a) of any foreign application(s) for patent or inventor's certificate or of any PCT international patent application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent, utility model, design registration, or inventor's certificate or any PCT international patent application(s) designating at least one country other than the United States of America filed by me for the same invention and having a filing date before that of the application(s) from which the benefit of priority is claimed.

PRIOR FOREIGN PATENT, UTILITY MODEL, AND DESIGN REGISTRATION APPLICATIONS, BENEFIT CLAIMED UNDER 35 USC §119(a)						
COUNTRY	PRIOR FOREIGN APPLICATION	DATE OF FILING (day,month,year)	PRIORITY CLAIMED UNDER 35 USC §119(a)			
Switzerland	1469/99	August 09, 1999	X	YES		NO
				YES		NO
				YES		NO

I claim the benefit pursuant to 35 USC §119(e) of the following United States provisional patent application(s):

PRIOR U.S. PROVISIONAL PATENT APPLICATIONS, BENEFIT CLAIMED UNDER 35 USC §119(e)	
APPLICATION NO.	DATE OF FILING (day,month,year)

I claim the benefit pursuant to 35 USC §120 of any United States patent application(s) or PCT international patent application(s) designating the United States of America listed below and, insofar as the subject matter of each of the claims of this patent application is not disclosed in the prior patent application(s) in the manner provided by the first paragraph of 35 USC §112, I acknowledge the duty to disclose material information as defined in 37 CFR §1.56 effective between the filing date of the prior patent application(s) and the national or PCT international filing date of this patent application.

PRIOR U.S. PATENT APPLICATIONS OR PCT INTERNATIONAL PATENT APPLICATIONS DESIGNATING THE U.S., BENEFIT CLAIMED UNDER 35 USC §120					
U.S. PATENT APPLICATIONS			Status *(check one)*		
SERIAL NUMBER	U.S. FILING DATE		PATENTED	PENDING	ABANDONED
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2.					
3.					
PCT APPLICATIONS DESIGNATING THE U.S.			Status *(check one)*		
PCT APPLICATION NO.	PCT FILING DATE	U.S. SERIAL NOS. ASSIGNED (if any)	PATENTED	PENDING	ABANDONED
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5.					
6.					

As a named inventor, I appoint the following attorneys to prosecute this application and transact all business in the Patent and Trademark Office connected with this patent application.

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I authorize my attorneys to accept and follow instructions from _____ regarding any matter related to the preparation, examination, grant, and maintenance of the patent application identified above, any continuation, continuation-in-part, or divisional patent application based on the patent application identified above, and any patent issuing from that patent application, until I or my assigns withdraw this authorization in writing.

I declare that all statements made herein of my own knowledge are true, that all statements made on information and belief are believed to be true, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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